OSD DEPUTY DIRECTOR OF DEFENSE RESEARCH & ENGINEERING
SMALL BUSINESS INNOVATION RESEARCH PROGRAM

PROGRAM DESCRIPTION

Introduction

The Army, Navy and Air Force hereafter referred to as DoD Components acting on behalf of the Office of Technology Transition in the Office of the Director, Defense Research and Engineering, invite small business firms to submit proposals under this program solicitation entitled Small Business Innovation Research (SBIR). Firms, with strong research and development capabilities in science or engineering in any of the topic areas described in this section and with the ability to commercial the results are encouraged to participate. Subject to availability of funds, DoD Components will support high quality research and development proposals of innovative concepts to solve the listed defense-related scientific or engineering problems, especially those concepts that also have high potential for commercialization in the private sector.

Objectives of the DoD SBIR Program include stimulating technological innovation, strengthening the role of small business in meeting DoD research and development needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing the commercial application of DoD-supported research and development results.

The DoD Program presented in this solicitation strives to encourage technology transfer with a focus on advanced development projects with a high probability of commercialization success, both in the government and private sector. The guidelines presented in this solicitation incorporate and exploit the flexibility of the SBA Policy Directive to encourage proposals based on scientific and technical approaches most likely to yield results important to DoD and the private sector.

Three Phase Program

Phase I is to determine, insofar as possible, the scientific or technical merit and feasibility of ideas submitted under the SBIR Program and will typically be one half-person year effort over a period not to exceed six months. Proposals should concentrate on that research and development which will significantly contribute to proving the scientific and technical feasibility of the proposed effort, the successful completion of which is a prerequisite for further DoD support in Phase II. The measure of Phase I success includes evaluations of the extent to which Phase II results would have the potential to yield a product or process of continuing importance to DoD and the private sector. Proposers are encouraged to consider whether the research and development they are proposing to DoD Components also has private sector potential, either for the proposed application or as a base for other applications. If it appears to have such potential, proposers are encouraged, on an optional basis, to obtain a contingent commitment for private follow-on funding to pursue further development of the commercial potential after the government funded research and development phases.

Subsequent Phase II awards will be made to firms on the basis of results from the Phase I effort and the scientific and technical merit of the Phase II proposal. Phase II awards will typically cover 2 to 5 person-years of effort over a period generally not to exceed 24 months (subject to negotiation). Phase II is the principal research and development effort and is expected to produce a well defined deliverable product or process. A more comprehensive proposal will be required for Phase II.

Under Phase III, the small business is expected to use non-federal capital to pursue private sector applications of the research development. Also, under Phase III, federal agencies may award non-SBIR funded follow-on contracts for products or processes which meet the mission needs of those agencies. This solicitation is designed, in part, to encourage the conversion of federally sponsored research and development innovation into private sector applications. The federal research and development can serve as both a technical and pre-venture capital base for ideas which may have commercial potential.

This solicitation is for Phase I proposals only. Any proposal submitted under prior SBIR solicitations will not be considered under this solicitation; however, offerors who were not awarded a contract in response to a particular topic under prior SBIR solicitations are free to update or modify and submit the same or modified proposal if it is responsive to any of the topics listed in this section.

For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that were awarded Phase I contracts, and have successfully completed their Phase I efforts, will be considered. DoD is not obligated to make any awards under either Phase I, II, or III. DoD is not responsible for any money expended by the proposer before award of any contract.

The Fast Track provisions in section 4.0 of this solicitation apply as follows. Under the Fast Track policy, SBIR projects that attract matching cash from an outside investor for their Phase II effort have an opportunity to receive interim funding between Phases I and II, to be evaluated for Phase II under an expedited process, and to be selected for Phase II award provided they meet or exceed a threshold of "technically sufficient" and have substantially met their Phase I technical goals, as discussed in Section 4.5. Under the Fast Track Program, a company submits a Fast Track application, including statement of work and cost estimate, within 120 to 180 days of the award of a Phase I contract. Also submitted at this time is a commitment of third party funding for Phase II. Subsequently, the company must submit its Phase I Final Report and its Phase II proposal no later than 210 days after the effective date of Phase I, and must certify, within 45 days of being selected for Phase II award, that all matching funds have been transferred to the company. The company will receive phase II contract award within an average of five months from the end of Phase I.

Follow-On Funding

In addition to supporting scientific and engineering research and development, another important goal of the program is conversion of DoD-supported research and development into commercial products. Proposers are encouraged to obtain a contingent commitment for private follow-on funding prior to Phase 11 where it is felt that the research and development has commercial potential in the private sector. Proposers who feel that their research and development have the potential to meet private sector market needs, in addition to meeting DoD objectives, are encouraged to obtain non-federal follow-on funding for Phase III to pursue private sector development. The commitment should be obtained during the course of Phase I performance. This commitment may be contingent upon the DoD supported development meeting some specific technical objectives in Phase II which if met, would justify non-federal funding to pursue further development for commercial purposes in Phase Ill. Note that when several Phase II proposals receive evaluations being of approximately equal merit, proposals that demonstrate such a commitment for follow-on funding will receive extra consideration during the evaluation process. The recipient will be permitted to obtain commercial rights to any invention made in either Phase I or Phase II, subject to the patent policies stated elsewhere in this solicitation.

Contact with DoD

General Information questions pertaining to proposal instructions contained in this solicitation should be directed to:
the point of contact identified in the topic description section of this solicitation. Proposals should be mailed to the address identified for this purpose in the topic description section. Oral communications with DoD personnel regarding the technical content of this solicitation during the Phase I proposal preparation periods are prohibited for reasons of competitive fairness.

OSD Deputy Director of Defense Research & Engineering
FY 1998 Topic Descriptions
ARMY, Natick Research, Development & Engineering Center (NATICK)
Technology Focus Area: Lightweight Warrior Systems
The dismounted soldier is central to all land operations. In order to accomplish his mission effectively he must be able to move efficiently over variable terrain. The soldier is overloaded by the weight of the items that he must carry. This weight presently approaches 200 pounds which is unacceptable as a combat load. In an effort to reduce the combat load of the soldier, the U.S. Army Natick RD&E Center has identified seven topics that focus on technology areas where improvements can be made to reduce the load carried by the soldier. The focus area, Lightweight Warrior Systems, includes a range of technologies related to the sustainment, survivability and support of the soldier. Individual topics include textile technology for multi- functional uniforms and garments, including composite technology for body armor, electronically conductive garments, sustainment systems and power sources.
The topics presented have wide commercial application in

addition to military relevance. The offerors should give strong consideration to commercial application of the project results when developing proposals.
MAIL PROPOSALS FOR TOPICS
OSD98-001 THROUGH OSD98-007 TO: Commander
U.S. Army Natick RD&E Center
ATTN: SSCNC-AE (Gerald Raisanen)
Kansas Street
Natick, MA 01760

OSD98-001 TITLE: Light Weight Warrior Protective Enclosures

TECHNOLOGY: Textile Technology

OBJECTIVE: Apply tubular textile technology to produce a seamless 1-2 soldier enclosure that will provide the warrior with improved protection, reduced weight and cube.

DESCRIPTION: Recent breakthroughs in textile manufacturing technology have demonstrated the ability to fabricate seamless tubular textile structures. This effort will transition emerging technology to the manufacture of a seamless shelter suitable for 1-2 soldiers. Seamless technology will result in faster production rates (reduced cost), reduced weight, reduced cube and the elimination of water leakage associated with seams.

PHASE I: Refine fabric construction to optimize physical characteristics such as weight and strength. Design and fabricate initial prototypes.

PHASE II: Incorporate any design refinements identified in Phase I. Fabricate final prototypes and test in the military and commercial marketplace. Address technical and quality issues related to full scale production.

DUAL USE COMMERCIALIZATION: Commercial backpacking tent manufacturers are constantly trying to reduce the weight of their products while offering the most competitive price. This technology could easily be transitioned into the commercial backpacking tent industry.

REFERENCE:
1. Required performance requirements are included in the purchase description for Tent, Combat, MARCORSYSCOM-PD-97-002, 17 April.
2. "Textiles: Fiber to Fabric, Sixth Edition", Bernard Corbman, 1983.

OSD98-002 TITLE: Multi-threat Protective Uniform System

TECHNOLOGY: Multi-functional Textile Materials, Uniform Systems

OBJECTIVE: To combine emerging material and system design/manufacturing technologies to develop a multi-layer, mission tailorable uniform system with the capabilities and protection necessary to address the environmental, chemical, flame/thermal, electrostatic, POL, and signature detection hazards that may be encountered on the battlefield of the 21st century across a broad temperature range at a 20 percent reduction in weight and bulk over current clothing items.

DESCRIPTION: The military has historically developed clothing items to defeat individual battlefield threats, e.g., cold weather clothing system, separate from a flame resistant uniform system. This results in a soldier requiring many layers of clothing, each providing a specific protection, which is also very heavy and bulky and inhibits soldier combat effectiveness. This effort should characterize the behavior and performance of a system by determining the cumulative effect of state-of-the-art/emerging material technologies on flame/thermal protection, environmental protection and heat stress when combined at the uniform system level, and assessing their impact on the performance of the warrior.

PHASE I: Define materials system alternatives. Test composite system configurations to evaluate their thermal conductivity and moisture vapor permeability characteristics. Determine which configurations provide the most efficient thermal insulation and compatibility with integrated technologies. Conduct Thermal Protective Performance (TPP) testing to measure the performance and behavior of the composite systems under flame. Provide recommendations for optimal material configuration alternatives and the data to support those recommendations.

PHASE II: Utilize best configurations from Phase I to fabricate prototype multifunctional uniform system(s). This may require development of novel manufacturing techniques (seaming) and leveraging novel closure systems technologies. Conduct articulated mannequin testing to evaluate their thermal conductivity and moisture management characteristics under controlled chamber conditions. Conduct flame/thermal testing using Thermo Man and Temperature Regulating System (TRS) to determine the influence of design on the performance of the materials systems under flame and against thermal pulse. Optimize the system and produce prototypes for a field study to assess mobility/maneuverability, durability, and efficiency of the uniform system's ventilation features in aiding thermoregulation and integration with other equipment.

DUAL-USE COMMERCIALIZATION: This systems approach for multi-threat protection has commercial potential in the following markets: Fire fighting service, industrial workers, chemical/HAZMAT, hunting, and recreational sports. This provides opportunities for small businesses to penetrate the textile industry manufacturing base via their technical innovations.

REFERENCES:
1. Endrusick, T. L. and Neilsen, R., (1990), Localized temperatures and Water Vapor Pressures within the Clothing of Working Man in the Cold. U.S. Army Res. Inst. Of Environ. Med., Natick, MA, Oct. 5, Series No. AD-A256 511.

2. Sutphin, Michelle, (1992), Conductive Grids vs. Intimate Blends with Conductive Fibers as Alternatives to Topical Antistatic Treatments, U.S. Army Natick RDEC, Natick, MA Technical Report Number TR-92-029
3. Greene, Charles A. et al, (1992), Operational Forces Interface Group Soldier Enhancement Program, User Evaluation of the Enhanced Hot Weather Battledress Uniform, U.S. Army Natick RDEC, Natick, MA
4. Tucker, David W., Sampson, James B. and Rei, Stephen A., (1990), Front End Analysis of Flame Hazards, U.S. Army Natick RDEC, Natick, MA. Technical Report TR-90-046L, AD B147304L
5. Sampson, James B., Tucker, David W. and Ridgeway, Debra C., (1989), Analysis of Combat Hazards for Balanced Protection, U.S. Army Natick RDEC, Natick, MA. Technical Report TR-90-012L
6. A Technical Information Package (TIP) is available from the Defense Technical Information Center.

OSD98-003 TITLE: Electro Optic Fabric Concepts for Combat Clothing

TECHNOLOGY: Microelectronics, conductive textile materials, fiber optics, micro sensors

OBJECTIVE: Integrate a conductive electronic/optical network within prototype garments constructed from wearable fabric.

DESCRIPTION: The first step to integrate microelectronics into the soldier system is to develop a wearable electronic network. The network will support sensor/monitor and actuator attachments and interconnections fed by a computer processor and transmitter. This effort will develop conductive network materials, sensor attachment techniques, textile seaming methods, and will result in the fabrication of prototype(s) ECG for proof of concept. The network may ultimately support a variety of environmental or chemical sensors, may provide for an active two way antenna system for transmitting and receiving voice/data information, or may supply power from a central battery to sensors remotely mounted to the soldier's extremities. Future alert detection systems may also require interconnection to a computer processor to signal the soldier of the presence of a mine, the enemy, chemical/biological agents, etc. [Note: Technologies developed may also be applicable to tentage and airdrop fabrics].

PHASE I: The technical feasibility to integrate an electronic network within a wearable fabric will be established. Potential conductive materials, yarn and textile fabrication processes, seaming techniques, sensor mounting and connection technology, distributed chip mounting technology, processor attachment and interconnection technology, and inter-garment electrical and optical interconnect technology and other technologies will be investigated. The most effective materials and processes will be determined and proposed for Phase II efforts. The target garment shall also be comfortable to wear (flexible, lightweight, non-irritating to the skin), resist corrosion and water contamination, and durable to wear and tear. Efforts should be made to shield the network system from electromagnetic interference. The study will result in a trade-off analysis comparing performance, manufacturing, and safety.

PHASE II: The most promising concepts of Phase I will be expanded and laboratory trials conducted. Small quantities of developmental materials and seams will be manufactured and tested. Full-scale manufacturing issues will be resolved and pilot production runs completed. A working prototype garment will be supplied.

DUAL-USE COMMERCIALIZATION: This technology has a potentially wide reaching commercial market as interest in wearable computers spreads from academia to the general public. Developing the textile and microelectronics connection opens the possibility to an infinite number of clothing applications as sensor and software development grows. Specific applications include toxic smoke and intense heat sensors for fire-fighters, toxic chemical sensors for industrial workers, temperature regulating clothing, and a tracking systems for prisoners.

REFERENCES:
1. Pentland, Alex, "Smart Room, Smart Clothes", Media Laboratory, MIT, 20 Ames St., Cambridge, MA, sandy@media.mit.edu, http://www-white.media.mit.edu/vismod
Pentland, Alex, (1996), Smart Clothes, Scientific American, pp 73, April 96

OSD98-004 TITLE: Elastomeric Perm-Selective Materials for Chemical Biological (CB) Protective Clothing.

TECHNOLOGY: Membrane Textile Technology

OBJECTIVE: To develop, demonstrate, and transition elastomeric, selectively permeable materials that will serve as a foundation for one-size-fits-all garments.

DESCRIPTION: Chemically-resistant, waterproof, and breathable polymeric materials with unusually high stretch-and-recoverable ratio and low creeping behavior will be developed for use in the development of a new generation of CB protective clothing and closure system. The resulting materials will be used as stepping-stone foundation for development of a new generation of one-size-fits-all clothing and CB agent-proof closure systems. This will eliminate the needs for overgarment, undergarment, and multiple garment sizes thereby reducing costs, weight, and logistic concerns and problems that soldiers currently face. Selecting a "right" polymeric material that has properties and characteristics as mentioned above has been identified as a major challenge in developing a closure system for CB protective clothing.

PHASE I. Design and analyze experiments using computer assisted software. Formulate and compound material formulations as identified by the experimental design.

Produce and test laboratory-size materials (6" wide) for their durability, elastic properties (ability to be stretched and recovered), protective barrier properties toward CB agents in liquid, vapor, and aerosol forms, and their ability to allow diffusion of water vapors. Government-developed test equipment will be utilized in measuring the permeation of water and chemical agent simulant vapors. Identify most promising formula(s). Prepare final report.

PHASE II. Produce scale-up pilot-plant size (40" wide) test material using Phase I's most promising formulation . Laminate stretchable perm-selective materials onto stretchable knit fabric. Fabricate clothing and closure system for functional and field-wear demonstration.

DUAL-USE COMMERCIALIZATION. Produce wide-width (60" wide) fabric. Fabricate and field test garments and closures for soldier's acceptance. The stretchable selectively permeable materials, when incorporated into fabric systems will be very attractive for dual-use in protective clothing applications for military uses, counter-terrorism, law-enforcement, industrial and pesticide chemical handlers/workers. It will also have many spin-off applications in the civilian market where one-size-fits-all concept is attractive and a closure system is needed.

REFERENCES:

1. Storey, R. F. and Shoemake, K. A., "Synthesis and Characterization of Novel Multi-Arm Star-Branched Polymers Based on Poly(Styrene-b-Isobutylene) Block Copolymer Arms," Polymer Preprints, Vol. 37, No. 2, pp. 321-322, American Chemical Society Papers presented at the Orlando, Florida Meeting, Aug 1996.
2. Mauritz, K. A. and Storey, R. F., "Block Copolymer Elastomer/Inorganic Hybrid Materials That are Resistant to Chemical Warfare Agents," U.S. Army Research Office Currently-FundedEPSCoR program (Dr. D. Kiserow's Office), 1996.
3. Brady, T. E., Jabarin, S. A. and Miller, G. W., "Transport Properties of Oriented Poly(Vinyl Chloride)," H. B. Hopfenberg, Permeability of Plastic Films and Coatings to Gases, Vapors, and Liquids, Polymer Science and Technology, Volume 6, p. 301-320, Borden Award Symposium, 1974, Plenum Press, New York and London.
4. Rogers, C. E., Yamada, S. and Ostler, M. I., "Modification of Polymer Membrane Permeability by Graft Copolymerization," H. B. Hopfenberg, Permeability of Plastic Films and Coatings to Gases, Vapors, and Liquids, Polymer Science and Technology, Volume 6, p. 155-166, Borden Award Symposium, 1974, Plenum Press, New York and London.

OSD98-005 TITLE: Pocket-stove

TECHNOLOGY: Combustion

OBJECTIVE: To develop a pocket sized stove that will burn logistics fuels (diesel and JP8) to provide hot water for dehydrated rations, beverages (coffee and cocoa) and limited personal hygiene, and provide basic technology for small heat driven devices including, personnel warmers, heat driven coolers (microclimate and beverages), lanterns, thermophotovoltaic generators, and infrared markers.

DESCRIPTION: Soldiers have no acceptable method for heating water. Trioxane fuel bars have historical supply problems. Commercial camp stoves (8-10K BTU/hour) are too large and heavy for infantry, and none will burn diesel fuel. Accordingly, new approaches and new technology must be explored that will enable a pocket sized stove with an output of 1-2K BTU/hour weighing not more than 4 ounces (2 ounces desired), that connects to a standard fuel bottle (i.e., commercial), that can heat 16 ounces of water in a canteen cup by 100F in less than ten minutes, and that will cleanly and safely burn diesel and JP8.

PHASE I: Establish the basic operating concept through the design and development of a proof-of-principle prototype, demonstrate operation and reliability, and provide strategies to meet all described requirements with minimal risk. Address safety and human factors.

PHASE II: Refine the design to meet all requirements and fabricate 100 prototypes for technical and operational tests. Address manufacturability issues related to full scale production for military and commercial utilization.

DUAL-USE COMMERCIALIZATION: Camp stoves for backpacking are oversized for individual use. Newer models are lighter, but they all rely on the same basic technology. A fundamental change in technology to lower output, size, and weight would revolutionize the industry. Commercial applications also include emergency heating and lighting devices.

REFERENCES:
1. Pickard, D. W., "Development of a Multifuel Individual/Squad Stove," Natick/TR-90/020, February 1990.
2. Fuel, Trioxane, Ration Heating MIL-F-10805
3. Stand, Canteen Cup MIL-S-44221

OSD98-006   TITLE: Evaluation Environment for Light Weight, Low Power Concepts

TECHNOLOGY: Engineering Modeling, Simulation, Computer Aided Design

OBJECTIVE: Investigation and development of a prototype Virtual Evaluation Environment to support engineering level assessment/exploration of individual protective clothing, shelter, and nutritional items in high fidelity simulated settings that accurately recreate actual use environments.

DESCRIPTION: Requirements to fully quantify and assess the potential impacts of new, light weight individual clothing and equipment, food, shelters, and ground mobility items continue to increase. During the envisioned effort an end-to-end virtual evaluation environment will be created that supports exploration of proposed new, changed, or enhanced individual clothing and equipment, food, shelters, and ground mobility items. In this environment the available fidelity will support: examination of the effects resulting from small changes in item characteristics; rapid execution numerous simulation iteration for each set of variable pairings to establish statistically significance of proposed changes; parametric analysis of potential item characteristic changes; and examination of the relationship between item characteristics changes and changes in human behavior, performance, quality of life, and survivability.

PHASE I: During Phase I the contractor shall: a) examine previous efforts to develop a virtual engineering level evaluation environments; b) identify the required models to build an individual protective clothing, shelter, and nutritional items virtual engineering level evaluation environment; and c) develop a prototype objected oriented architecture for a prototype individual protective clothing, shelter, and nutritional items virtual engineering level evaluation environment.
PHASE II: During Phase II the contractor shall develop, document and demonstrate a prototype individual protective clothing, shelter, and nutritional items virtual engineering level evaluation environment.

DUAL-USE COMMERCIALIZATION: There is a growing need to be able to study, assess, and demonstrate the effect on human behavior, survival and performance that changes in nutrition, clothing, shelter, or activity will have. Offsetting this growing need is an inability, due to regulations and laws, to expose human subjects in many of the exact situations for which the information is most needed. A high fidelity individual protective clothing, shelter, and nutritional items virtual engineering level evaluation environment will allow both military and civilian researchers to better understand the effects proposed changes without unnecessarily expose people to hazardous environments in order to collect data.

REFERENCES:
1. Garcia, A., Goecke, R. Jr., and Johnson, N., Virtual Prototyping, Report of the Defense Systems Management College (DSMC) 1992-1993 Military Research Fellows, Fort Belvoir, VA, DSMC Press, 1994.
2. DMSC Systems Acquisition Manager's Guide for the Use of Models and Simulations, DSMC Press, September 1994.

OSD98-007 TITLE: Polymer Electrolyte Batteries

TECHNOLOGY: Polymer Science, Electrochemistry

OBJECTIVE: To develop rechargeable polymer batteries with high specific energies and specific power, based on polymer electrolytes synthesized by enzyme catalyzed reactions.

DESCRIPTIONS: Future rechargeable batteries for the individual soldier require high specific energies (>150 Wh/kg) and high specific power (>40 W/kg) over a temperature range of -400 C to +700 C. Batteries based on polymer electrolytes have advantages over existing power sources for this application. To meet the above requirements, polymer-based electrolytes require a) high conductivity at the ambient temperatures, b) good physical and thermal stability, c) chemical compatibility with electrode materials, and d) high recharging efficiency. Conductivity of solvent-free polymer electrolytes presently known are too low at ambient temperatures to be useful. The highest conductivity achieved to date is ~10-5 S/cm at room temperature. Hence, there is a need to develop polymer electrolytes with significantly higher conductivity and stability than the present generation materials, and develop batteries from these polymer electrolytes. It is necessary to pursue unusual approaches in order to develop polymer electrolytes having conductivity of the order of 10-3 S cm-1. Studies carried out at Natick with enzyme-catalyzed reactions have indicated that tailored polyaromatic compounds may be synthesized with functional groups (such as carboxylic and sulfonic groups) with well defined molecular weight and dispersity. Polymers synthesized from functionalized monomers are expected to have high conductivity, with good thermal, physical and chemical stability.

PHASE I: Efforts will be to identify monomer candidates with functional groups for the enzyme-based polymerization. Polymers synthesized will be characterized for physical and chemical stability, and electrolyte properties identified. Reaction conditions will be modified for optimum yield, molecular weight and dispersity. Usefulness of the electrolytes for batteries will be demonstrated in laboratory cells.
PHASE II: Efforts will be on formulations of selected polyphenols with different plasticizers to reduce the crystallinity and Tg of the polymer electrolytes. Electrolyte formulations will be evaluated in laboratory cells and prototype batteries. Conductivity of electrolyte formulations developed are expected to be significantly higher than that of present generation

DUAL-USE COMMERCIALIZATION: There are a number of potential applications for light weight rechargeable batteries based on polymers and without the use of toxic and corrosive metals. There is a need for these type of batteries in automobile, electronic parts and devices, and energy sources for survival, safety and communication equipment.

REFERENCES:
1. Akkara, J. A. Senecal, K. and Kaplan, D. L. J. Polymer Sci.: Part A; Polymer Chem. 29, 1561-1574 (1991).
2. Ayyagari, M. S., Akkara, J. A., et al. Macromol. 28, 5192-5197 (1995).

AIR FORCE, DEFENSE AIR RECONNAISANCE OFFICE, Advanced Development Division (ADD) / Wright Laboratory

Technology Focus Area: Airborne Remote Sensing

The Defense Airborne Reconnaissance Office (DARO) is responsible for providing the warfighter assured access to reconnaissance in the theater. This assured access implies new developments in sensors, processing, and communications -- while striving for greater commonality, reliability, and lower life-cycle costs. Achieving this balance between enhanced capability and lower cost is often achieved through selective investment in developing technologies. Often the developing technology is driven by the commercial industry and requires only a modest investment to adapt the technology for airborne applications. One pillar of this investment strategy is the use of SBIRs to foster the necessary research and development of these emerging technologies.

The following SBIR topics support both commercial and military applications for airborne (and spaceborne) remote sensing. These topics represent high risk yet potentially high payoff for both the DARO and the commercial sector. DARO selected these topics based upon the following criteria:

* Crucial to "Airborne Remote Sensing"
* Offer potential for the highest payoff
* Support both DoD and Commercial use

The following topics formed together support areas of interest for the DARO and support the guidelines for the OSD SBIR Technology Transfer Program.

MAIL PROPOSALS FOR TOPICS
OSD98-008 THROUGH OSD98-016 TO: DARO
Attn: Mike Eisman
ASC/RAP Bldg 557
2640 Loop Road West
WPAFB, OH 45433-7106
phone: (937) 255-3575

OSD98-008 TITLE: High Data Rate Solid State Storage of Data

TECHNOLOGY: Airborne Remote Sensing

OBJECTIVE: The next generation reconnaissance sensors will exceed the capability of the current data storage devices. What is needed, is a high data throughput, low bit error rate (BER), digital storage device capable of operating in an airborne environment.

DESCRIPTION: Advancements in military and commercial sensors have resulted in airborne, space, ground and water based systems that collect a tremendous volume of high-resolution imagery. Mechanical recording systems have to date been used to store and disseminate this data. The amount of data to be collected in the future from a single sensor platform, however, is anticipated to exceed the capability of current and projected mechanical storage systems. In addition, mechanical systems are prone to poor reliability and other system errors (hardware/software, communications errors, processing errors, etc.). Fortunately, recent advances in solid state memory modules could meet the anticipated data storage needs. No work, however, is being done in applying these high density solid state memory modules to airborne data storage devices. The offeror should, therefore, address the requirements, development, and demonstration of a solid state memory system capable of meeting the data storage requirements. The proposed system should be capable of storing 500 Gbps - 1,500 Gbps with an I/O of 3 - 10 Gbps with a maximum Bit Error Rate 1E-14. The system shall be highly reliable, maintainable, power consumption less than 100W, and packaged to fit within a volume of less than 1.5 cubic feet.

PHASE I: Perform industry surveys and meet with customer technical personnel to establish the performance and operational requirements demanded of the solid state system. From this listing of requirements develop a design package clearly describing the desired product.

PHASE II: Execute necessary engineering development on desired unit then build and demonstrate proof-of-concept real-time sensor data acquisition and storage system based on the design package developed in Phase I. Provide a performance assessment which will allow for future extrapolation of the technique to various tactical reconnaissance platforms both manned and unmanned. At the conclusion of Phase II, the government will have a fully developed unit ready for Phase III production and use throughout the field.

DUAL-USE COMMERCIALIZATION: Demonstration of the full potential of this technology promises to provide significant payoff in a broad spectrum of information processing applications having major commercial and military significance. This technology is directly applicable for commercial airborne systems that perform terrain mapping, environmental monitoring, geological sensing, agricultural monitoring, and archeological investigations. This technology directly supports surveillance, reconnaissance, and intelligence communities military requirements for real time acquisition, storage and exploitation of sensor data.

OSD98-009 TITLE: Investigate Using Network Protocols on Asymmetric RF Datalinks.

TECHNOLOGY: Airborne Remote Sensing

OBJECTIVE: Perform computer simulation and modeling of performance of transmitting/receiving ATM cells through an asymmetric Department of Defense airborne RF data link called the Common Data Link.

DESCRIPTION: The DoD Common Data Link is an asymmetric wideband X or Ku-band RF data link used for airborne-to-ground and airborne-to-airborne data applications. The data link may have 10.7, 137, or 274 megabit/s downlink data rates, but only 5 to 200 kilobit/s uplink rates. The DARO is interested in characterizing the performance and effects of using ATM network protocols with an asymmetric data link such as CDL, to transmit and receive MPEG compressed video, still imagery, or other products in an environment where the bit error rate (BER) could range from 10e-3 to 10e-12, with NSA crypto devices and forward error correction in the data link, with or without jamming.

PHASE I: The offeror shall develop computer modeling and/or simulation software to predict data link performance, limitations, and operational constraints on use leading to a Phase II prototype.

PHASE II: The offeror shall develop a prototype using the technical data developed under Phase I. The prototype shall be tested using DoD equipment to validate Phase I products and predictions.

DUAL USE COMMERCIALIZATION: Application to commercial air transport industry for high rate airborne data communications.

OSD98-010 TITLE: Phased Array Antennas

TECHNOLOGY: Airborne Remote Sensing

OBJECTIVE: Feasibility of/performance characteristics for Unmanned Aerial Vehicles, manned aircraft, etc., operating with LEO or HEO satellite constellations for air-SATCOM wideband RF data links.

DESCRIPTION: DARO is interested in operating low (10,000 feet) to high altitude (65,000 feet) airborne systems with low earth orbit, medium earth orbit, or high earth orbit communications satellites to reduce size, weight, power, and aperture requirements on the airborne vehicles vice operating with geo-synchronous orbit satellites. Small aperture, twin-beam, steerable, full duplex conformal phased array antennas are an enabling technology to maintain continuous communications with orbiting satellites as they rise above and disappear over the horizon. The hypothesis is that with a twin beam phased array, the air vehicle could electronically switch from communicating with one satellite to the next without a lapse in communications, and without exceeding size, weight, or power constraints. DARO desires to investigate the feasibility of this technology in the 11 GHz to 40 GHz RF spectrum, operating at 2 megabit/s to 600 megabit/s data rates. DARO specifically desires to investigate the possibility of using this antenna technology with future planned systems.

PHASE I: Technical design study, tradeoff analyses, and feasibility assessment of current and projected future state of the art phased array and RF switching technologies of a twin-beam, steerable, full duplex conformal phased array antenna in the 11 Ghz to 40 GHz RF spectrum, operating at 2 to 600 megabit/s data rates to achieve this capability before the year 2010.

PHASE II: Build a prototype antenna system technology for a airborne or static mountain-top demonstration.

DUAL USE COMMERCIALIZATION: Application to commercial air transport industry for high rate airborne data communications.

OSD98-011 TITLE: Small Size, Multifrequency, Multibeam Phased Array Antenna Systems

TECHNOLOGY: Airborne Remote Sensing

OBJECTIVE: Determine the technical feasibility of using multi-frequency, multibeam full duplex phased array antennas to allow a ground control station to simultaneously receive and transmit data with up to 2,3, or 4 airborne systems, such as Unmanned Aerial Vehicles.

DESCRIPTION: DARO is developing or already has in the inventory systems using C, X, or Ku-band RF data links. Each flying system has an associated unique ground station. DARO desires to investigate the possibility of using a single ground station transmitter to simultaneously send and receive to multiple airborne systems to reduce ground station footprint, uniqueness, and requirement for a one-to-one correlation between airborne system and ground system. Data rates vary from 1.544 megabits/s to 274 megabits/s downlink rates, 64 kilobits/s to 10.7 megabits/s uplink rates. Small physical size suitable for tactical use desired.

PHASE I: Technical design, performance characteristics of, and cost estimates for antenna system.

PHASE II: Technical demonstration of a prototype antenna system.

DUAL USE COMMERCIALIZATION: Commercial shipboard or building top terrestrial uses where accessibility, or space (volume) restricted data communications applications require frequency agility and multiple beams.

OSD98-012 TITLE: Advanced Compact Antenna Technology

TECHNOLOGY: Airborne Remote Sensing

OBJECTIVE: Demonstrate enhanced antenna element gain for small lightweight synthesize virtual antennas to achieve greater performance than the physical antenna element would allow. The goal is to achieve improved signal-to-noise performance in weak and/or adjacent/co-channel interference environments with very compact antennas.

DESCRIPTION: Develop a mathematical model to support the improved performance of a multi-element synthesized virtual antenna. Develop a single prototype element and a prototype synthesized virtual antenna system. Demonstrate the synthesized virtual antennas capabilities for a small lightweight airborne antenna application.

PHASE I: Develop a mathematical model approach and simple model that demonstrates the improved antenna array performance using synthesized virtual antenna technology. Prototype a single element VHF, UHF, SHF antenna element that demonstrates meaningful improved gain and greater instantaneous bandwidth that can be flush mounted/conformal to flat or curved surface.

PHASE II: Build and demonstrate a prototype antenna system for full characterization in antenna anechoic chamber or antenna outdoor range.

DUAL USE COMMERCIALIZATION: Candidates for dual use include cellular communications and personal/wireless communications. These applications would benefit from the greater bandwidth and/or improved signal-to-noise achievable in a cluttered frequency range.

OSD98-013 TITLE: Object-Level Change Detection

TECHNOLOGY: Airborne Remote Sensing

OBJECTIVE: Demonstrate processing techniques to determine changes in the presence or position of objects in a scene, while ignoring changes in local or overall scene illumination.

DESCRIPTION: Simple change detection algorithms for imagery may operate by detecting changes in illumination of images. These techniques suffer from false alarms due to differences in illumination conditions between the two frames being compared. Object-level change detection algorithms are based on the ability of the processing to segment an image into areas corresponding to distinct objects. Changes in the status of objects are then detected, due to movement of objects into or out of a scene or within the scene. In addition to the benefits of increased false-alarm immunity, object-level change detection allows a degree of machine understanding of the changes. For example, disappearance of an object in one location and appearance of a similar object in a new location could indicate object movement.

PHASE I: Propose one or more processing algorithms to detect changes in object status and define several scene conditions of military vehicles under various levels of illumination with vary degrees of background clutter, with partial target obscuration and aspect geometry.. Perform preliminary assessment of the algorithm against these scene conditions.

PHASE II: Conduct a detailed evaluate of the performance of the algorithms against the variety of scene conditions. The algorithms can be used in conjunction with existing government or private sector algorithms that may provide parts of the solution.

DUAL USE COMMERCIALIZATION: Candidates for commercial application of this technology include aided target recognition systems for battlefield awareness, and commercial security monitoring systems.

REFERENCES: SAIP Technical Overview Meeting, March 4,1997, available from DARPA; Moving and Stationary Target Acquisition and Recognition (MSTAR) High Performance Computing Demonstration, April 28, 1997, available from DARPA.

OSD98-014 TITLE: Optimized Data Compression for Hyperspectral Imaging

TECHNOLOGY: Airborne Remote Sensing

OBJECTIVE: To develop a lossless compression algorithm that utilizes redundant information both spatially and spectrally.

DESCRIPTION: Hyperspectral imagers can now be procured that are both reliable and fairly inexpensive. This technology availability is fostering a revolution in the military and commercial remote sensing community. The biggest hurdle, however, is the volume of data obtained with one of these instruments. Recording or downlinking the raw data is often prohibitively expensive. For many applications, degrading the data by applying a lossy compression, invalidates the results. The desired algorithm should determine the maximum lossless compression possible given the spectral/spatial hypercube and efficiently compress the data. If an asymmetric encoding/decoding scheme is utilized, it would be preferable to have the majority of the computation in the encoding.

PHASE I: Develop an optimized lossless compression scheme for spectral/spatial hypercubes. Phase I should be able to demonstrate the optimal nature of the algorithm via compression of readily available hypercubes and demonstrating its lossless nature.

PHASE II: Implement the compression scheme so as to operate in near real-time on data rates of > 100 Mbits/s. The implementation can consist of field programmable gate arrays (FPGA), ASICs, or other hardware/software that meets the data rates.

DUAL USE COMMERCIALIZATION: Commercial interest in hyperspectral technology is growing quickly. Several commercial enterprises are currently using airborne instruments to monitor agricultural health and environmental monitoring. In addition, several companies are investigating employing hyperspectral imagers in space for remote sensing applications. The compression algorithm developed under this program would reduce the amount of data storage necessary as well as decrease the required communications bandwidth.

OSD98-015 TITLE: Flexible Hyperspectral Dispersive Elements

TECHNOLOGY: Airborne Remote Sensing

OBJECTIVE: To develop a flexible bandwidth spectral dispersive element.

DESCRIPTION: Exploitation of hyperspectral imagery is currently hampered by the volume of data collected. Current methods detect entire spectrum. however, only certain regions of the spectral information are needed. In fact, most schemes need narrow bands in some regions and only coarse resolution in others. This proposal is to enable the technology for producing low cost custom-design spectral dispersive elements with flexible band centers and bandwidths.

PHASE I: This phase should provide a design including estimates of through-put and spectral cross-talk on the focal plane array using an array of holographic optical elements or rugate interference filters. The design should provide a flexible band centers and bandwidth optimized to spectral bands of interest. The design should minimize the total number detectors for spectral measurements.

PHASE II: Prototype the flexible bandwidth dispersive prototype optical system and demonstrate its performance.

DUAL USE COMMERCIALIZATION: The flexible dispersive optical system is an enabling technology for hyperspectral imaging. The ability to tailor the spectral bandwidths for various commercial applications would allow for a potentially lower cost, more compact system to be fielded for remote sensing applications.

OSD98-016 TITLE: Optical Field Flatteners for IR Hyperspectral Sensors

TECHNOLOGY: Airborne Remote Sensing

OBJECTIVE: To produce a high-quality, low cost field flattener for infrared hyperspectral sensors.

DESCRIPTION: The dispersion elements for hyperspectral sensors separate the spectrum in angle. Focal planes, however, are 2-D detectors with pixels of constant dimensions. These attributes force a trade between preserving spectral bandwidth constancy and having a wide field-of-view (FOV) system. Conventional glass field flatteners cannot accommodate the larger field curvatures. This effort will concentrate on using IR optical fibers to provide the necessary field flatness.

PHASE I: Optical fibers have been used in the visible as field flatteners in the 0.4-1.0 micron region. Optical glass exists in the SWIR region and some fibers have been extruded. The Phase I effort will investigate potential SWIR glass fibers (1.0-2.5 microns) and measure the transmission and insertion losses. System performance will be estimated for a hyperspectral system employing the SWIR optical fibers as field flatteners.

PHASE II: A fiber optical bundle will be integrated into a wide FOV SWIR hyperspectral sensor. The goal is to provide a minimum of 45o FOV. Throughput, spectral purity, and spatial MTF will be measured.

DUAL USE COMMERCIALIZATION: Providing a low cost, wide FOV IR hyperspectral system will impact two commercial areas.

The first is the burgeoning commercial remote sensing industry utilizing aircraft and spacecraft. The second field is in nondestructive testing which utilizes the spectral information to verify yield and quality in many material formation and fabrication processes.

NAVY, Theater Air Defense PEO - Naval Surface Warfare Center, Dahlgren Division
Technology Focus Area: Modeling and Simulation

Modeling and Simulation processes, methods, tools, and environments are needed for engineering large-scale, distributed, complex systems consisting of a heterogeneous mix of physical processes (sensor, communications and control, actuators) interacting with a dynamic environment. The principal Theater Air Defense application domains that embody systems of systems characteristics are Theater Ballistic Missile Defense, Littoral Battle-Space, and Global Command and Control. Other DOD applications include Total Ship System Engineering, Expeditionary Warfare, and Information Warfare. Corollary application domains in the commercial sector include air traffic control, telecommunications, electrical utilities, rapid transit systems. Typically, each component within the systems needed to address the foregoing problem domains is a system itself. A high degree of connectivity and computing capability is required in order to support the information and decision making processes in such systems. Complexity exists at different levels within the system of systems architecture, creating a tendency toward mathematical intractability in the analysis and design of these systems. A broad range of stakeholders must be enabled to participate effectively in the development and deployment processes in order to assure that the product delivered satisfies the original requirements. Integrated product teams (IPT) representing a number of engineering disciplines must employ a disciplined approach in a concurrent engineering fashion to engineer the intended product.
Integrated enterprise environments based on advanced information technologies must support the employment of processes, methods, and tools which assure management of complexity and enable IPT's to perform design synthesis, evaluation and assessment, and life-support of large scale systems. These environments must leverage the best available modeling and simulation technology in order to support engineering analyzes for large-scale systems without the need for extensive prototyping in hardware and software of candidate designs.

The following topics support the commercialization of advanced systems of systems modeling and simulation methods and tools for both DoD and the private sector.

Mail Proposals for Topics #OSD98-017 through OSD98-020 to:
Ron Vermillion
Naval Surface Warfare Center
Code B04, Bldg. 1470/1104
17320 Dahlgren Rd.
Dahlgren, VA 22448-5100

OSD 98-017   TITLE: Information Flow Analysis Capability

TECHNOLOGY: Modeling and Simulation

OBJECTIVE: Develop information flow analysis capability to define, chart, analyze, and visualize the information elements flowing among a set of objects (platforms, systems, human decision makers) in a complex-adaptive theater warfare system.

DESCRIPTION: A military theater of operation is a complex, dynamic, system of interacting objects constantly adapting to changes in the theater environment. These adaptations are based on the various objects in the theater system acquiring information about the environment, identifying patterns in that information, defining action models based on those patterns, and making decisions to act in some manner on the basis of those models. This process occurs with the human decision makers throughout a chain of command as well as the systems those decision makers use to support their actions. Understanding the information flow and the interactions of information elements within this complex and ever-changing environment is critical to being able to conceptualize and design theater systems and processes.

PHASE I: Define system modeling and analysis processes by which information elements may be defined from functional requirements, how elements are related, and how elements are derived from other elements thru correlation or fusion schemes (both machine and human). Show visually these processes, especially the flow of information from one subsystem to another. Demonstrate how the interaction of information elements influences their evolution over time. Present possible designs for an Information Flow & Analysis Tool. The designs should take advantage of current WEB and database technology, be based on a modular architecture, and be capable of interfacing with wargame simulation systems.
PHASE II: Develop and test the Information Flow and Analysis Tool based on the Phase 1 design. The tool should demonstrate a basic capability to define information flows and to be able to visualize those flows and their various interactions so that the uninitiated can grasp an overall understanding of the information environment of a complex theater of operation. The tool should also demonstrate an ability to support the analysis of information flows. Phase 2 will also demonstrate the tools ability to interface with an existing theater simulation system.

DUAL-USE COMMERCIALIZATION: This system has great commercial and DoD potential in supporting the conceptualization and design of various complex, information-rich systems where humans are responsible for making key decisions. Candidate applications include private sector financial and investment systems or military data banks and fire control solutions.

REFERENCES:
Lectures in the Science of Complexity, Ed. D. Stein, Addison-Wesley, 1989"Theory and Applications of Information-Based Complexity" by J. F. Traub and H. Wozniakowski, 1990
Lectures in Complex Systems, Edited by L. Nadel and D.

Stein, Addison-Wesley, 1991

OSD 98-018 TITLE: Visualization of the Effects of Architectural Failure for Large-Scale High Assurance Systems

TECHNOLOGY: Modeling and Simulation

OBJECTIVE: To provide engineers with tools which will aid early understanding of how large, complex systems can fail.

DESCRIPTION: It has been known for years that the earlier that errors in requirements (also design and implementation) are discovered, the less costly they are to fix. By integrating failure analysis tools with modeling and simulation tools which provide for visualization of behavior, the goal of early recognition of requirements and design errors can be realized. The result of this effort will help fully integrate failure analysis into the system development process, thus aiding the understanding of the behavior of large, complex systems when subsystems fail.

PHASE I: Survey the literature for techniques, methods, and tools which could serve as candidates for integration with existing visualization tools. Construct a framework for the visualization of system failure, and plan the development of an initial prototype. The plan will include the identification of the major semantic issues to be overcome in the tool integration process.
PHASE II: Implement the Phase I plan: perform the tool integration, and build a prototype to demonstrate the utility of the concept. Provide support for a Navy Program using the prototype. This will serve as an initial transition to the Navy.

DUAL-USE TECHNOLOGY: Application of the tool to Navy programs, such as theater missile defense, or large platform procurement such as the SC-21 or CV-X. Commercial applications include aircraft and telecommunications systems design.

REFERENCES:
1. Design and Analysis of Fault Tolerant Systems, by Barry W. Johnson, Addison-Wesley Publishing Company
2. "Real-Time Object-Oriented Modeling", Bran Selic, Garth Gullekson, Paul T. Ward, John Wiley & Sons Inc., 1994.

OSD 98-019 TITLE: Human Engineering Tools for Engineering of Complex Systems

TECHNOLOGY: Modeling and Simulation

OBJECTIVE: The purpose of this project would be to develop an integrated set of performance prediction, performance evaluation, workload assessment, and decision support tools for assessing the human engineering aspects of US Navy and commercial system designs within a "systems engineering" (SE) framework. The tool set will be used to evaluate reduced manning and automation concepts for new and evolving large-scale designs.

DESCRIPTION: The Navy needs tools to plan for, design, and evaluate alternative manning and automation concepts (with the goal of reducing crew sizes) prior to implementing specific technologies and designs. While there are a number of tools currently available that can provide designers and analysts with assistance in evaluating these issues, the currently available tools fall short in several key areas. 1) Available tools are not specifically applicable to human system integration issues associated with shipboard manning and the unique team requirements and associated workload issues. 2) Those tools that do exist are designed more for post-design analysis, versus engineering the human operator into the design at the outset. 3) Human engineering considerations of the operator as an integral "system" component are not yet supported in any systems engineering tool sets.
An integrated tool set that can perform some set of the following functions will greatly augment current system modeling and analysis capability: a) capture and articulate engineering requirements specific to the human operator, b) weigh the costs and benefits of human operators against automation, c) create candidate display concepts (based upon human factors principles), d) provide performance modeling, and e) perform individual and team workload analyses (including cognitive, perceptual, and motor workload). This integrated tool set must be compatible with existing databases of shipboard tasks and performance elements. Additionally, it must be capable of interacting with typical system engineering models.

This set of analytical tools for evaluating automation alternatives in quantitative, unambiguous terms would predict which alternatives would be most likely to result in successfully reducing manning within the domain of safe and effective shipboard operations. These tools are needed to address the allocation of functions and tasks to humans and to advanced technologies, evaluate the design of workstations, interfaces, jobs and procedures, as well as identify additional training requirements resulting from the introduction of new technologies.

PHASE I: Define the requirements for a toolset and define requisite information necessary to support tool development and usage. Identify candidate tools and develop estimates of manpower required to use the tools.
PHASE II: Implement a prototype integrated human engineering toolset in a commercially available workstation environment. Demonstrate the capability of the tools to address human engineering aspects of Navy systems.

DUAL-USE COMMERCIALIZATION: Potential applications include Navy (NSWCDD) ship acquisition to evaluate reduced manning and automation concepts for new and evolving ship designs. While manning reduction for the Navy is the primary thrust for this effort, applications include other stressful team environments such as air traffic control, nuclear power control, and crisis management centers.

OSD 98-020 TITLE: Virtual Prototyping Environments for The Development of Systems of Systems.

TECHNOLOGY: Modeling and Simulation

OBJECTIVE: Develop an integrated engineering environment which provides new capabilities to enable the prediction and evaluation of total system performance as well as system design trade-offs. Apply modeling and simulations, synthetic environment, and virtual reality technology to the implementation of virtual prototyping capabilities for the design, manufacture and test of systems of systems.

DESCRIPTION: Virtual Reality (VR) technology is advancing and maturing very quickly. VR technology is now being invested in and applied in many fields such as engineering, manufacturing, chemistry, aerospace, and medicine. The two greatest benefits of this technology have been significant reduction of cost and development time in these engineering disciplines. However, VR has not been substantially utilized in the area of system engineering. Because system engineering deals with large, complex, real-time systems of systems, the greatest benefits is in cost reduction in the system development process. This effort will develop and apply VR technology in concert with system modeling and analysis tools for application to integrated system engineering environments to enable virtual prototyping, virtual manufacturing, and virtual testing of candidate large-scale system designs. The following capabilities are critical in supporting virtual engineering environments:

a) Generic infrastructure and system engineering life-cycle support for large scale real-time systems
b) Distributed simulation support for integrated battlespace engineering and analysis
c) Resource optimization for large scale information systems
d) Wide area collaborative system engineering
e) Configuration management for distributed large, complex, real-time federated systems architectures

PHASE I: Perform a feasibility study and implementation specification for the development of Virtual Prototyping Environments. Develop specification and implementation plans and a recommendation for Phase II implementation.
PHASE II: Develop, test and demonstrate initial Virtual Prototyping Environment specified in Phase I effort for small or medium scale architecture.

DUAL-USE COMMERCIALIZATION: Application to Navy system acquisitions (e.g., SC21, CVX, LPD-17, NSSN). This application of VR is useful to any industry which engages in system engineering (e.g., the aerospace engineering and telecommunications industries).

REFERENCES:
1. Slater M., Usoh M. (1994) Body Centered Interaction in Immersive Virtual Environments, in "Artificial Life and Virtual Reality", Eds. N. Thalmann and D. Thalmann, John Wiley & Sons, England, 1994, pp125-147.
2. Department of Defense: High Level Architecture Object

Modeling Template Version 0.3 Defense, Modeling and Simulation Office. Alexandria, VA. May 1996
3. Department of Defense: High Level Interface Specification (Version 0.4) Defense, Modeling and Simulation Office, Alexandria, VA.
4. The Common Object Request Broker: Common Object Services Specification. Object Management Group. OMG Document Number 95-3-31, March 31, 1995

NAVAL AIR WARFARE CENTER, PATUXENT RIVER

Technology Focus Area: Health Monitoring of Navy Aircraft

The costs associated with a Safe Life maintenance philosophy are very high. As our fleet ages beyond their original design life these costs will continue to escalate as dictated by the ever shrinking inspection intervals. The need to move from a Safe Life maintenance philosophy to a Condition Based Maintenance (CBM) philosophy is imperative if we want to reduce life cycle costs while maintaining fleet readiness. As we approach the design life of existing platforms, Life Assessment Programs (LAP) will determine the condition of the platform. In many case this programs will be followed by Life Extension Programs (LEP). As part of the LEP, the specific platforms will go through a completely tear down giving the opportunity of installing CBM system. We must now develop such Health Monitoring System in order to integrate them in the LEP programs as they start developing in the near future. As part of this SBIR the following topics will be considered for award:

Distributed Crack Initiation and Growth Monitoring System
10 Distributed Corrosion Monitoring System
20 Distributed Bond line Monitoring system
30 Health Monitoring of Rotating Engine Parts

Mail Proposals for Topics #OSD98-021 through OSD98-024 to:
Carol Van Wyk
Naval Air Warfare Center - Aircraft Div R&D
22541 Milstone Road, Attn Code: 40C/T
Patuxent River, MD 20670-5304
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OSD 98-021 TITLE: Distributed Crack Initiation and Growth Monitoring System

OBJECTIVE: To develop a Distributed Acoustic Emissions (AE) monitoring system for the detection of cracks in metallic structural components using advance sensor techniques such as fiber optic sensors. The main requirements of this system is that all the sensors will be powered and interrogated with a single line such as a single optical fiber or a single coaxial cable. The system will be sensitive to frequencies in the 100KHz to 1 MHz band and it will detect the AE events in the presence of quasi-static loading. The loading state will also be determined using the same sensor system

DESCRIPTION: A system for reliably detecting cracks in aging aircraft structures and in next generation fighters is critically needed. AE monitoring is the only proven method of detecting cracks in metals without having to place the sensor directly in top of the cracks. However, present AE monitoring systems suffer from various limitations. Each sensor need two wire leads to pick up the signal, the wire leads have to be heavily shielded to avoid EMI, each sensor needs a pre-amplifier and signal conditioner nearby, two more wire leads are required for each amplifier. Techniques that use fiber optic Bragg gratings offer the opportunity of solving all these limitations. A single optical fiber will have embedded in it various Bragg grating sensors, all sensors will be interrogated using a single laser beam, and since there is no attenuation in the fiber there will be no need for pre-amplifiers or signal conditioners. Also, the system does not require EMI shielding since it is optical in nature.

PHASE I: In Phase I the contractor will demonstrate that he can monitor acoustic emissions in a loaded Aluminum panel by using the advanced sensor concept. The system will have a minimum of three sensors in a single power line. Acoustic emissions will be simulated by performing pencil break tests and/or by producing short burst of energy form an ultrasonic transducer. In the second case, the central frequencies of the burst will range from 100KHz to 1MHz in steps of 100KHz with approximately a 150KHz Band Width. The loading level will range from 10% to 60% of the yield strength of the aluminum plate. The sensitivity of the system will be compared theoretically and experimentally to that of a standard single channel AE transducer.

PHASE II: In Phase II the contractor will develop all the necessary optical and electronic components for a 10 channel Acoustic Emission monitoring system. It is advised at this point that the contractor team up with a airframe manufacturer interested in transitioning this new technology.

PHASE III: A health monitoring system of this nature could be installed in any DoD platform (F18, F14, F16, F15) which has a structural component (such as a bulkhead) that requires periodic inspections to ensure the lack of cracks. Significant cost savings could be achieved by the installation of this system by performing maintenance at longer time intervals or only when the system indicates that it is required.

COMMERCIAL POTENTIAL: Commercial aviation would benefit significantly from a system of this nature as well. Wide spread fatigue damage has been determined to be a major source of problem for commercial aviation.

REFERENCES:
1. "Fiber Optic Bragg Grating Model", I. Perez, T.F.A. Bibby, M. Ryan, Report No. NAWCADWAR-95027-4.3
2. Proceeding of "Smart Structures and Materials 1997" Sponsored by the SPIE Soc. - San Diego, CA, 3/97
3. ASTM-E976

OSD 98-022 TITLE: Distributed Corrosion Monitoring System

OBJECTIVE: To develop a distributed Corrosion Monitoring system capable of detecting the occurrence of corrosion in key structural components and monitoring its evolution and severity.

DESCRIPTION: It is well known that stress-corrosion cracking and corrosion fatigue can significantly reduce the life expectancy of structures. Therefore, it is critical to develop a monitoring system which can reliably and accurately detect the amount of corrosion experienced by a structure. In this way early and economic repairs can be performed to the structure at the same time that the useful life of the structure is extended. System concepts should be capable of detecting and monitoring the evolution of corrosion in hidden aircraft structural components such as inside lap joints, around fasteners and under aircraft skins.

PHASE I: In phase I a proof of concept will be performed. The amount of corrosion will be monitored in an environmental or salt spray chamber.

PHASE II: In Phase II a prototype Distributed Corrosion Monitoring system will be developed. System will be demonstrated in a fleet aircraft.

PHASE III: Phase III will identify funding source to transition this technology to NAVAIR and find a suitable industrial partner to develop a manufacturing process

COMMERCIAL POTENTIAL: A system of this nature has enormous applications in the civilian aviation sector by monitoring corrosion in aging aircraft's. This type of system could also monitor corrosion in bridges, pressure vessels, an in explosive environments where electrical sensor might produce a hazard.

OSD 98-023 TITLE: Distributed Adhesive Bond Monitoring System

OBJECTIVE: To develop a distributed health monitoring system capable of monitoring the integrity of adhesively bonded structures.

DESCRIPTION: The cost associated with periodic inspection of aircraft structures is astronomical. This cost will continue to rise as our fleet ages further with no new replacements for the short term. A health monitoring system could significantly reduce the cost of ownership by reducing or eliminating periodic inspections and replacing them with on demand inspections. Also the reliability of detection would be increased because the damage location could be triangulated before hand. The inspection time would be reduced because only the damaged site would be inspected and repaired.

PHASE I: In Phase I the contractor will demonstrate the proposed concept for monitoring the integrity of bond lines. The contractor will use standard aerospace adhesives (such as FM300 and AF191) and materials (such as Al7075 and Graphite epoxy composites) to demonstrate the technique.

PHASE II: In Phase II a prototype Distributed Adhesive Bond Monitoring system will be developed. System will be demonstrated in a fleet aircraft.

PHASE III: Phase III will identify funding source to transition this technology to NAVAIR and find a suitable industrial partner to develop a manufacturing process

COMMERCIAL POTENTIAL: A system of this nature has enormous applications in the civilian aviation sector by monitoring adhesively bonded structures in aircraft wings, fuselage, pressure vessels, an in explosive environments (fuel tanks) where electrical sensor might produce a hazard.

OSD 98-024 TITLE: Health Monitoring of Rotating Engine Parts

OBJECTIVE: To develop a distributed health monitoring system capable of monitoring the integrity of moving engine parts. The sensor system will be permanently installed in the engine and will have to compatible with the engine environment.

DESCRIPTION: The cost associated with periodic inspection of aircraft engines is astronomical. This cost will continue to rise as our fleet ages further with no new replacements for the short term. A health monitoring system could significantly reduce the cost of ownership by reducing or eliminating periodic inspections and replacing them with on demand inspections. Also the reliability of detection would be increased because the damage location could be triangulated before hand. The inspection time would be reduced because only the damaged site would be inspected and repaired.

PHASE I: In Phase I the contractor will demonstrate the innovative concept in a rotating turbine engine disk with blade. The contractor will demonstrate that when a small flaw (crack) is introduced in the disk or blade, his sensor system will be capable of detecting it.

PHASE II: In Phase II a prototype Rotating Engine Part Health Monitoring system will be developed. System will be demonstrated in a fleet aircraft.

PHASE III: Phase III will identify funding source to transition this technology to NAVAIR and find a suitable industrial partner to develop a manufacturing process

COMMERCIAL POTENTIAL: A system of this nature has enormous applications in the civilian aviation sector by monitoring rotating engine parts.

OSD-18